1893MNRAS..54...65A

On Errors that may arise in Estimating Star Magnitudes by Photography. By Captain W. de W. Abney, C.B., R.E., D.C.L., F.R.S.

In a recent paper read before the Photographic Congress held in October last I gave my results of experiments carried out with a view of investigating the interdependence of time of exposure and intensity of light. I found that when very feeble intensities of light were allowed to act for times proportionately longer than when a greater intensity was employed, so that in all cases the product of intensity and time were the same, the chemical action, or in other words the density, produced was by no means the same under certain conditions of sensitive surface. Now, I have often expressed the opinion that it should be the same, but have guarded myself by adding within limits. For instance, five years ago, when President of Section A of the British Association, I stated this more explicitly. I refer to this to justify myself against the charge of being inconsistent. I may also say that at the Paris conference on the stellar photographic map it was my intention to indicate the same, but I honestly say I was not prepared for such a break-down of the usually accepted law under some of the conditions under which the experiments were undertaken. The condition for a break-down is this, that if a slow plate be used—more particularly, I believe, if it be one which is a pure bromide—the products of time and intensity being a constant do not always give the same amount of chemical action. Now, this is a serious matter for the star-charts which are being prepared in accordance with the plans laid down at astro-photographic congresses, for it by no means follows that star magnitudes will always be the same when derived from different plates. I will show you a few examples on the screen of the results of the experiments made. In the first we have an example of a fairly rapid plate, which was exposed at varying distances from an amyl acetate lamp, with increased exposures for increased distances, so that the aforesaid product in every case was the same. It will be seen that the feebler the intensity of the light, the less the chemical action. The next slide shows this graphically, the transparency being measured from the negatives. It will be noticed that, in the case of the plate shown, when the intensity of the light is reduced to $\frac{1}{256}$, the apparent chemical action is only about $\frac{1}{4}$ what it should be, according to the ordinary assumption. The next slide gives the results in the shape of a table. Now let us apply this to the star magnitudes. Suppose such a plate be exposed so as to impress, say, a star of the 7th magnitude in a certain number of seconds; we should expect that to get one of the 11th

1893MNRAS..54...65A

magnitude we should have to expose for an equivalent number of seconds. Yet if we gave that exposure we should find that we had impressed the image of a star no brighter than one between the 9th and 10th, since what I call the equivalent exposure would not be more than $\frac{1}{4}$ what it would be expected to be. If this be the case, it is evident that any star magnitudes which were obtained would be untrustworthy, unless special precautions were taken, which I can indicate briefly. The scale of gradation of a plate when exposed for the same time to varying intensities of light at the same time is altered, as I can show you by plates exposed in a sensitometer. For instance, we have two plates—one of the same make already shown, and the other a very rapid plate—the number of gradations as shown by the squares which have been acted upon by properly graduated intensities of light were fewer in the first case than in the second. Now, the last visible square in each may be supposed to represent the faintest light that would make an impression in the given time, so that if exposures with both of them were given for times which would impress them with the star-disc of, say, a 1st-magnitude star of a certain diameter, the limit of higher magnitude stars which would be impressed would differ considerably. If we take it that in one case stars from the 1st to the 11th magnitude, and in the other stars from the 1st to the 7th magnitude, were shown (the diameters of the star discs of the 1st-magnitude star being the same in both cases), then the diameters of the star discs of the 6th magnitude on the one plate and of the 4th on the other would be very approximately the same, supposing they lie in the part of the curve which descends in the straight part of the curve. In other words, there would be a proportional diminution in the diameters of the star discs in the latter plate. If, then, the discs of two stars largely differing in magnitude but lying within the limits indicated be determined, those of the others may also be determined, supposing a formula for decrease in diameter with increase in magnitude has previously been arrived at. It must, however, be recollected that there are portions of the curve which are beyond the limits indicated, and here any comparison would fail. There is, however, one comfort, which is that a very rapid plate shows less deviation from the assumed law than a slower one; in fact, the more rapid the plate, the less the deviation that will be shown. Further, I have come to the conclusion that the composition of the sensitive surface has much to say to the results. I wish to guard myself against any rigid expression of opinion on this subject, as my experiments are as yet incomplete, but I fancy that a homoiodide plate will be found to have less deviation from the assumed law than a homobromide. Those who are interested in the subject know that there have been many curious differences in the star magnitudes as derived from a

1893MNRAS..54...65A

plate, and some observers have found that the time of exposure necessary to impress a higher magnitude star is greater than that which theoretically should be the case, and it seems probable that this result is due to the difference in behaviour of the plates used. It will probably turn out that each particular brand of plate will require a different formula for arriving at star magnitudes photographically, and that the formula which is suitable for one will not be suitable for another. I should like, in conclusion to this note, to point out a method by which an idea as to the suitability of a plate for stellar work can be obtained. In the investigations to which I have referred I also included the effect of a number of small exposures succeeding each other with varying rapidity, and I found that *the sum of a large number of small exposures was not equal to the same exposure given at one time*, and whether a plate were slow or rapid, it showed a break-down of the assumption usually made that such should be the case. Further, it was found that the longer the interval of rest between successive exposures the less the chemical action. The more rapid the plate the less this loss of energy appeared; in fact, it followed the rule found when the intensity of light was diminished. The plate placed in the lantern shows this, and the next slide shows the curve derived from it. It will be noticed how the chemical action falls off, whatever be the exposure.

Now, this affords a ready means of testing a plate, for if it fails largely with this test, it will fail also, to a certain extent, with the other. If a lamp of 1-candle power be placed at such a distance from the plate that 20 seconds' exposure gives a medium density to a portion of the plate, the remainder being covered up, and a sector with a 20° aperture be rotated in front of the beam some ten to twenty times a second for 360 seconds, a different part of the plate being exposed, then, should the densities given by the two exposures be within ·7 of one another, the plate may be considered practically to obey the usually assumed law, and star magnitudes can be obtained from all such plates, as the times of exposure for obtaining higher magnitudes will very closely coincide with those which are theoretically required.

The Secondary Colour Aberrations of the Refracting Telescope in Relation to Vision. By H. Dennis Taylor.

It is notoriously easy to grow so accustomed to a supposed necessary evil as to become practically oblivious of its presence. The astronomer who diligently uses his refracting telescope ceases to notice the ever-present halo of purplish light which surrounds the objects of his scrutiny, and is somewhat startled,